Abstract

The aim of this model is to build up the relationship between the change of color of our test paper and the concentration of HCV in the sample. We used RGB model to describe the color change in the reaction. And, we built up the relationship between RGB and concentration.

1.Introduction

The aim of this model is to find out the relationship between the color of our test paper and the concentration of HCV in the sample. We can determine the range of concentration of HCV by detecting the color of our test paper.

When applied with HCV, the toehold switch added ahead untied, exposed RBS and began translation. These robust biomolecular switches provide tight translational regulation over transcripts and exhibit excellent orthogonality.(Keith Pardee, Alexander A. Green, Tom Ferrante, D. Ewen Cameron, Ajay DaleyKeyser, Peng Yin, and James J. Collins, 2014) The enzyme b-galactosidase (LacZ) was expressed and caused the test paper to change color. We can detect the change in color and describe it quantitatively in RGB model.

1

1

In general, the model is built up by first finding out the values of red, blue and yellow (RGB) on the photo given by our resource[1] using Photoshop; these resources come from the use of Switch D. Then, it finds out the relationship between the percentage of RGB and time (RGB%-t). In the next step, several sources — the relationships between Absorbance of light-time (figure 1), the formula of relationship between absorbance and transmission of Switch D and Switch G— have been provided in paper[1]. Through these sources, we built up the relationship between RGB percentage and transmission (RGB%-T). By the graph of transmission-time(figure 2) [1] with different concentrations, we find out the relationship between concentration and transmissions at different time, and we built up the relationship between time and the parameters in this formula (C-T). By knowing RGB%-T, T-t, C-T, we can determine the concentration by knowing the RGB percentage value and time.

1. RGB

To start, we used Photoshop to detect the resultant color of switch D(figure3, Keith Pardee, Alexander A. Green, Tom Ferrante, D. Ewen Cameron, Ajay DaleyKeyser, Peng Yin, and James J. Collins, 2014). Our results are listed in table 1.

2

However, it is easy to see form table 1 that, the rate that RGB change within the same period of time is inconstant. That’s probably because of the impossibility to ensure that the intensity of light is the same every time a subject is tested. Therefore, instead of the raw data we choose to use the percentage of RGB, which is more

reliable than simply use the raw data.

3

Then, we construct the scatter dot graph of RGB%-t and find the best linear fit of each graph (Figure 4, figure5, figure6). For each linear function, the R^2 is closer to 1, indicating the fitness for the linear relationships.

4

5

6

The slopes of the graphs are the changing rates of each color..

2. Three dimensional model

we use the functions of RGB calculate the RGB values of 35 points of time during the time period from 25min to 60min, since the scatter dots in that period of time relatively fit the functions better. Then, we construct a three-dimensional RGB% graph(figure 7)

7

3. Transition between formulars.

Besides, there are several other relationships provided in the source[1]. They linked together absorbance between different switches, transmission, time and concentration (figure 8, figure 9, figure 10). We also knew the relationship between RGB% and time. Thus, through a series of transitions (flow chart), we came up with the relationship between RGB% and concentration.

Such an equation was provided in the source:

Along with the RGB%-t relationship we've already come up with, we get these relationships: 8

Another equation was also provided in the source:

9

In this way, we figured out the relationship between RGB%and transmission

10

However, we realized that the picture we used to detect at an earlier stage of our project is a result for switch D. But the graph dealing with concentration is drawn based on the experiments of switch G. Fortunately, there is a relationship between absorbance and transmission, which is true for all kinds of switches. We also have two graphs for switch D and switch G on absorbance-time(figure 8, figure 9)

11

Figure 8[source]

12

Figure 9[source]

13

Figure 10

14

Figure 11

The model has a good robust within the range of [0.8, 1.0].

15

Graph 12 is the graph dealing with transmission, time and concentration provided in the source[1]. We ignore the data from Switch G because they are unreliable and they are too close to Time. We picked the moments of 25min, 30min, 35min, 40min,45min, 50 min, 55min, 60min.(graph 13) We pick these dots because the time is within the range where the changes in relative transmission become constant.

For each of the moment, there are three points. We did the best fitting for each of the points. We found an exponential relationship between concentration and transmission, with time being a parameter:

15

(a and b are parameter depending on time)

16

Figure 12

17

Graph 13

18

19

Figure 13

20

Figure 13

The model has a good robust within the range of [0.8, 1.0].

To find out the relationship between transmission and time, we fit in a function.(figure14-21)

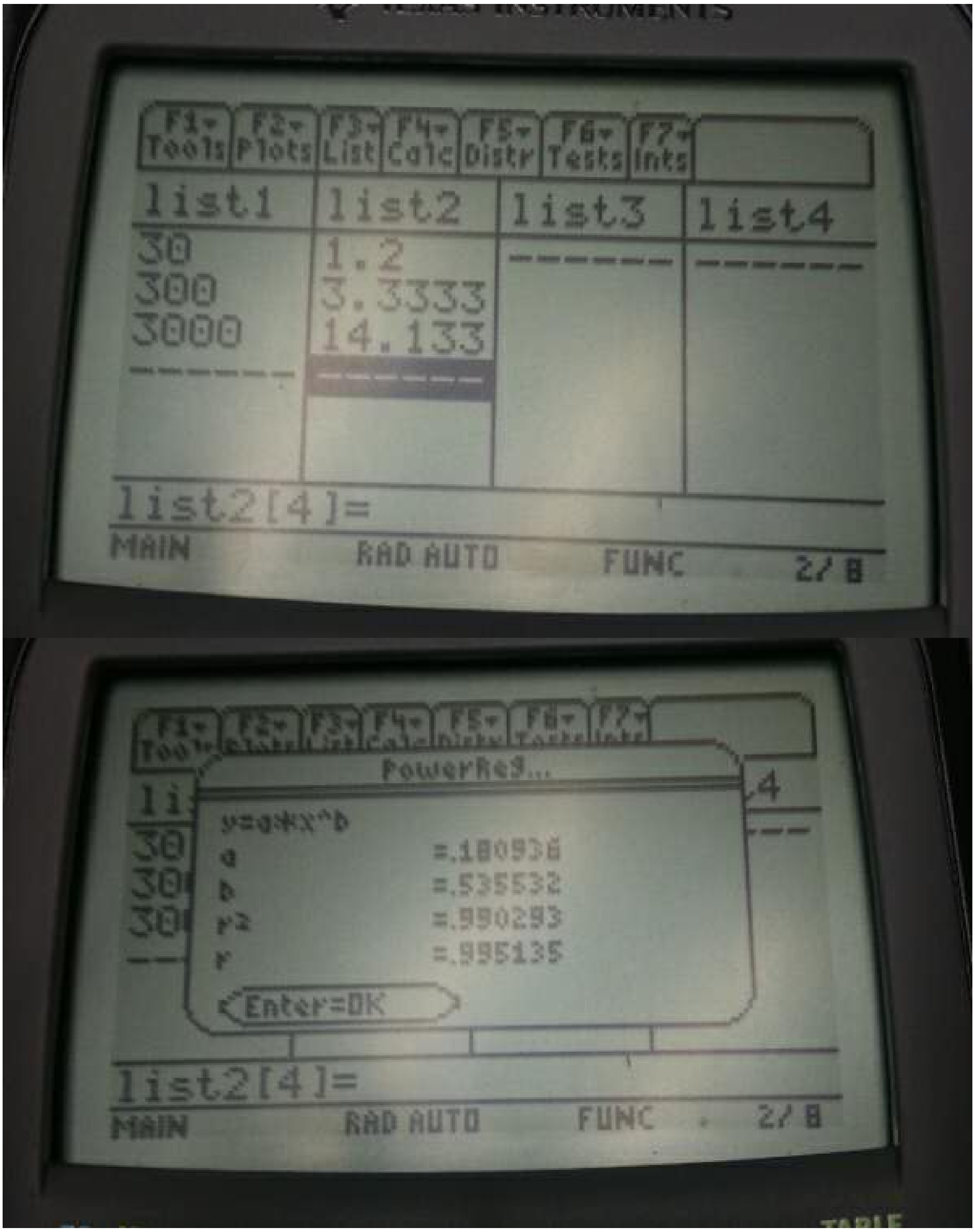


Figure 14(t=25)

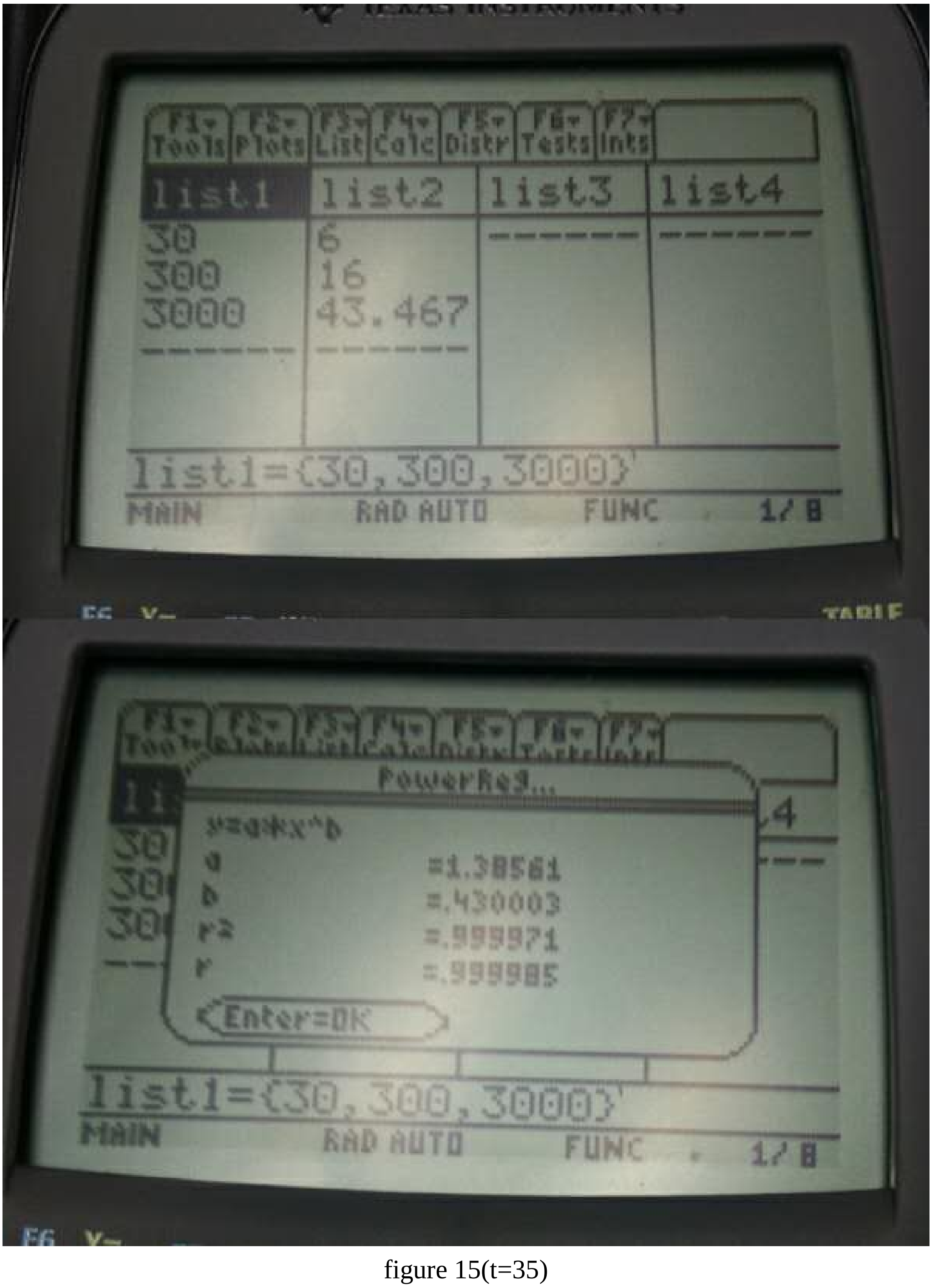


figure 15(t=35)

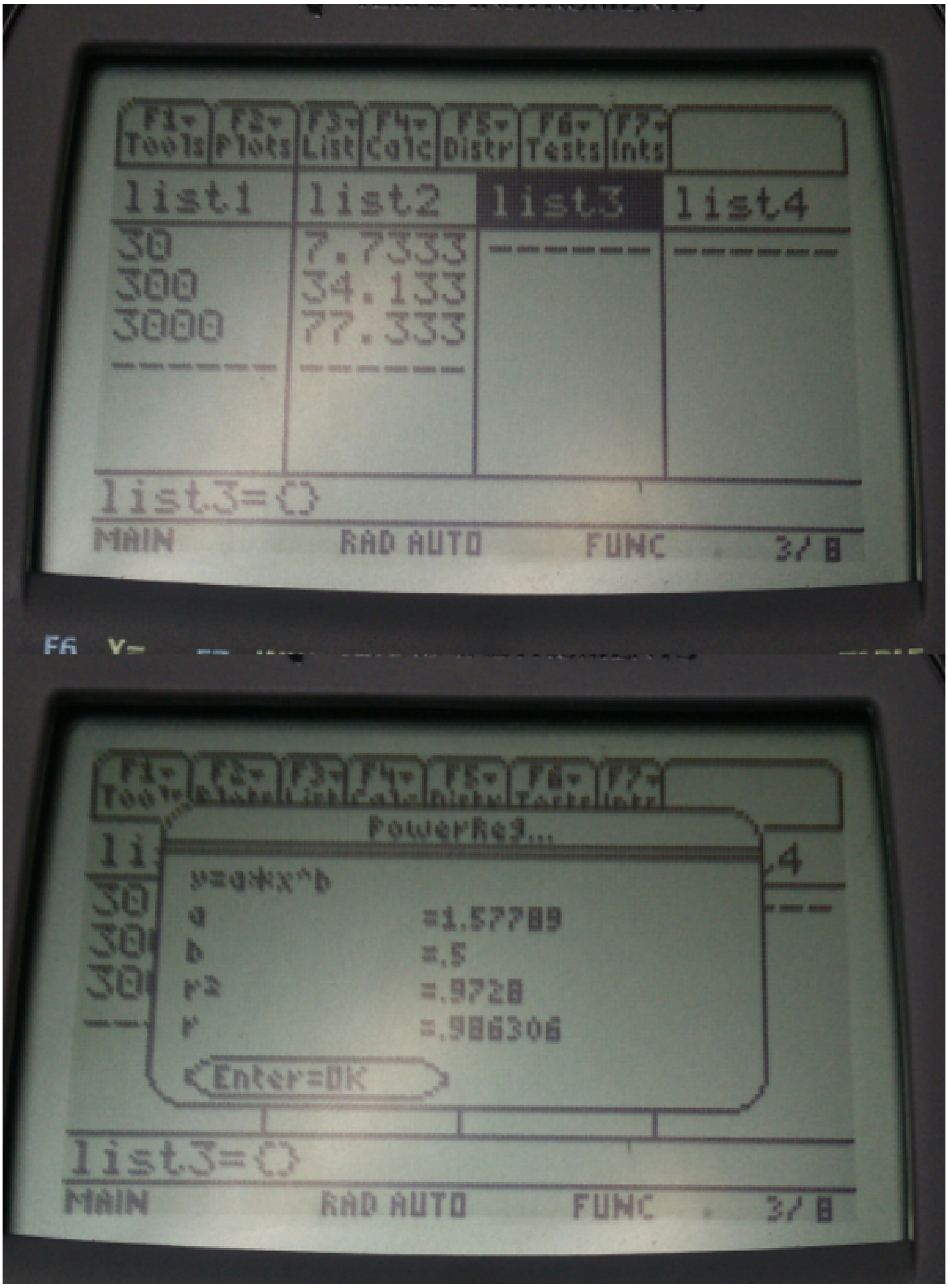


Figure 16(t=45)

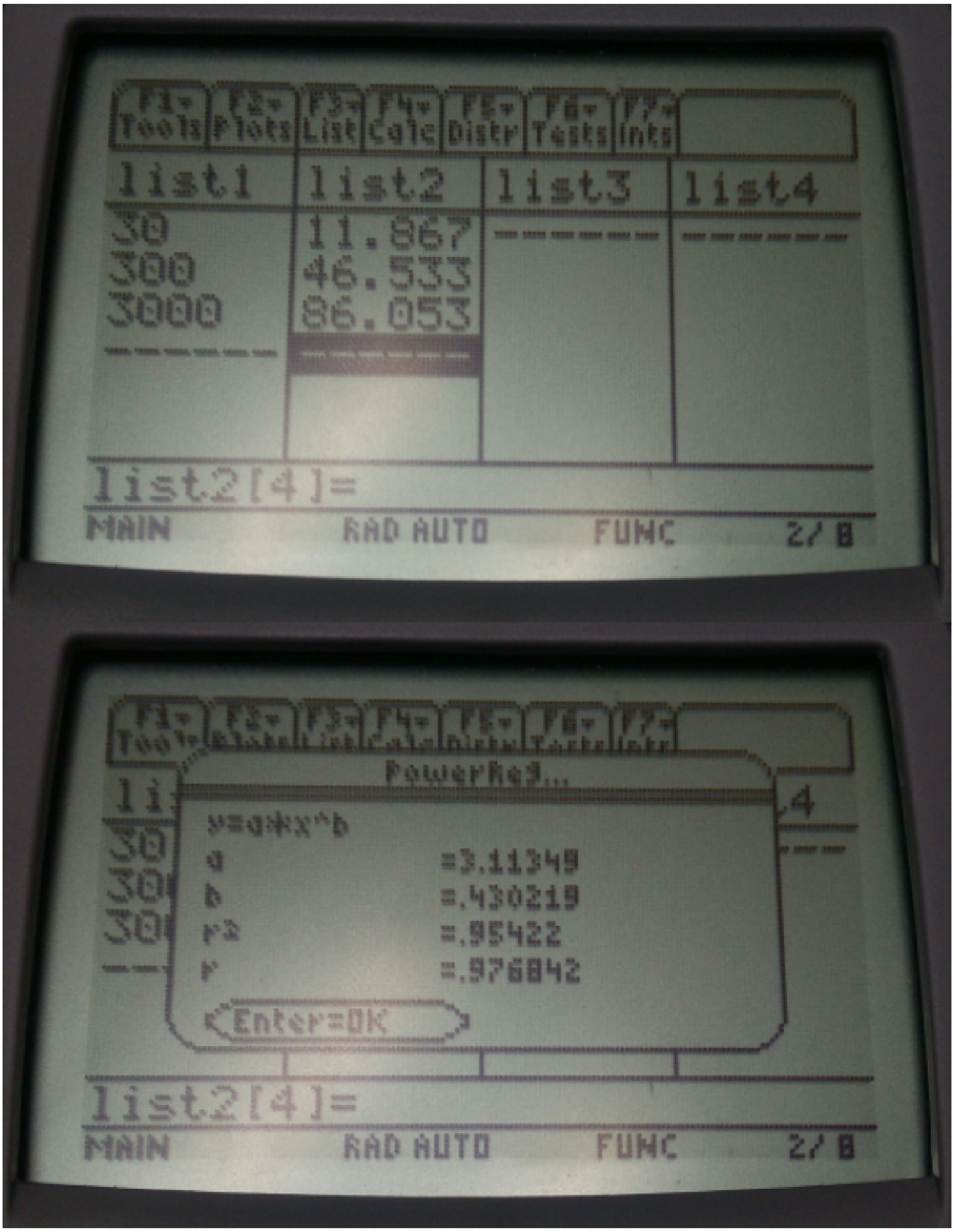


Figure 17(t=50)

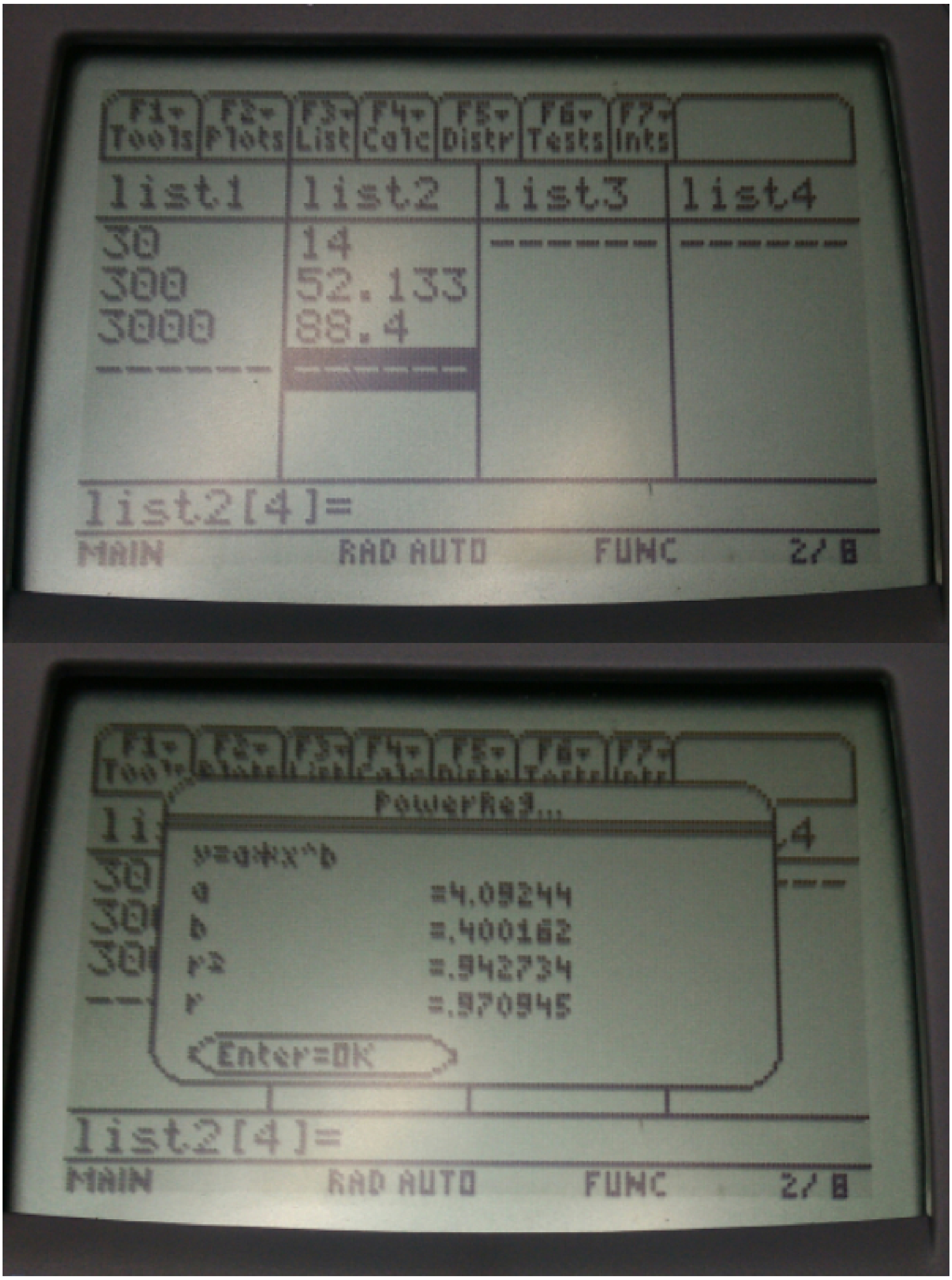


Figure 18(t=55)

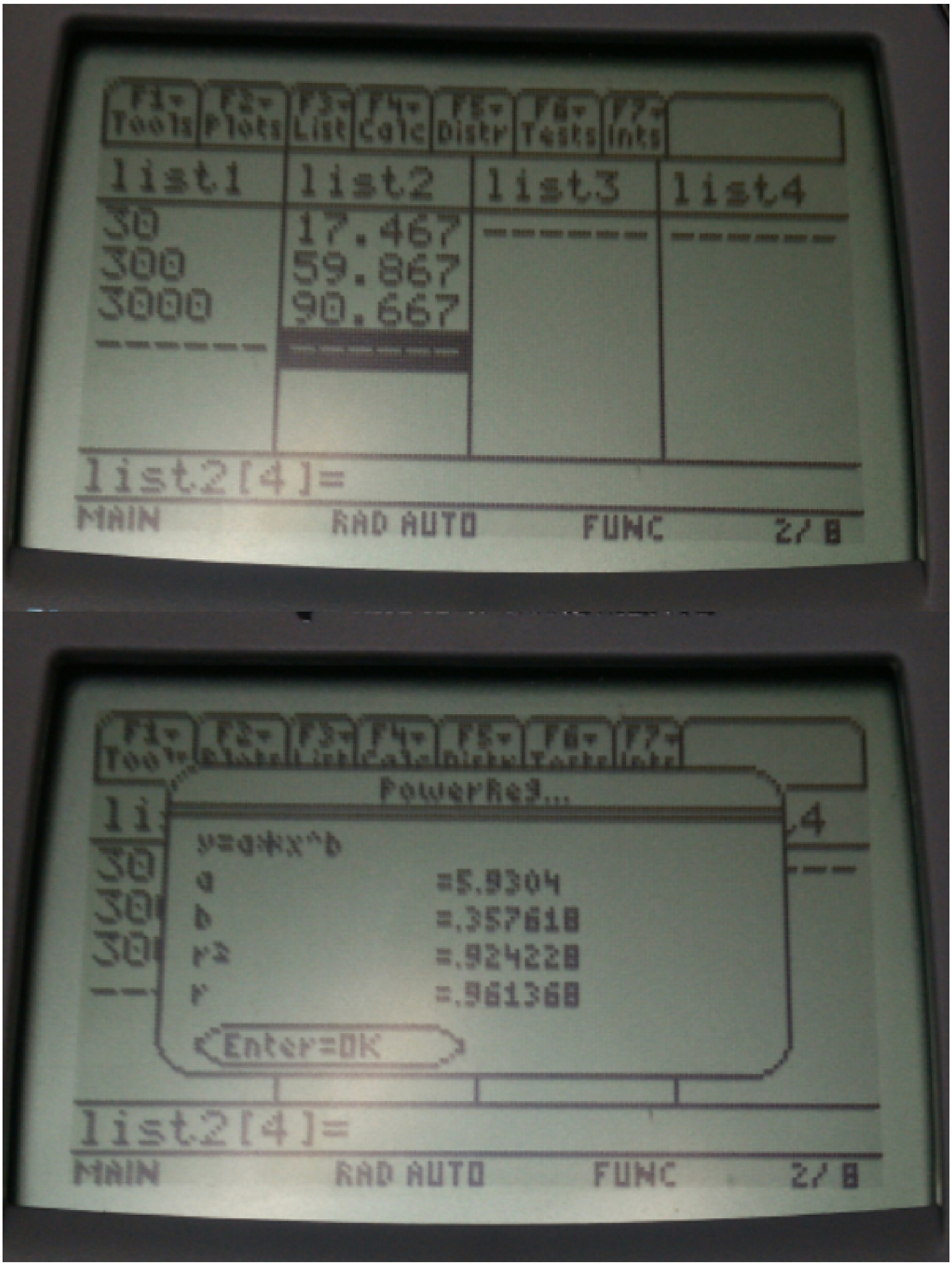
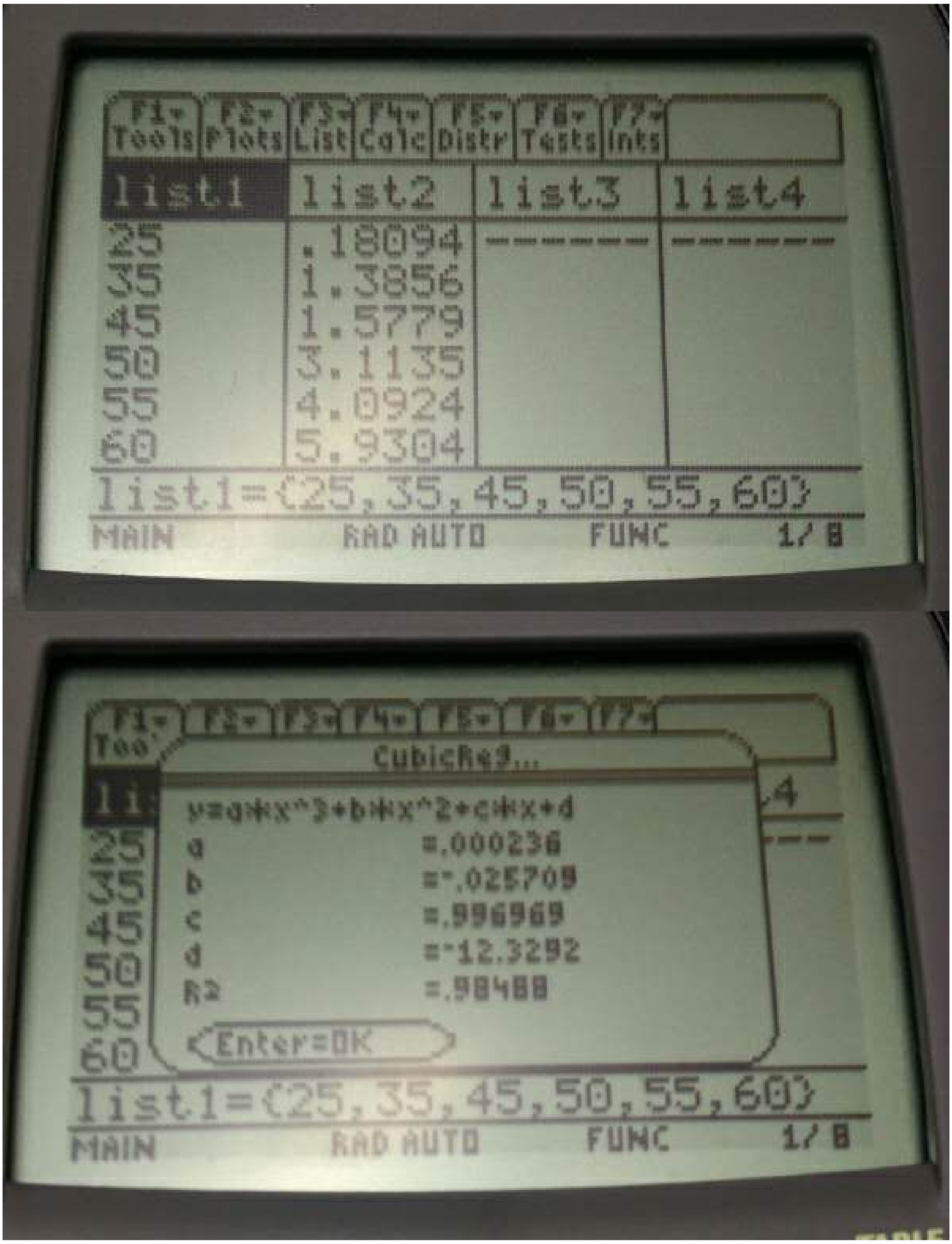


Figure 19(t=60)



F1 Tools
F2 Plots
F3 List
F4 Calc
F5 Distr
F6 Tests
F7 Ints
list1
list2
list3
list4
25 .18094
35 1.3856
45 1.5779
50 3.1135
55 4.0924
60 5.9304
list1={25,35,45,50,55,60}
MAIN RAD AUTO FUNC 1/8
CubicReg...
y=a*x^3+b*x^2+c*x+d
a =.000236
b =-.025709
c =.996969
d =-12.3292
R2 =.98488
Enter=OK
list1={25,35,45,50,55,60}
MAIN RAD AUTO FUNC 1/8

Figure 20 (a-t)

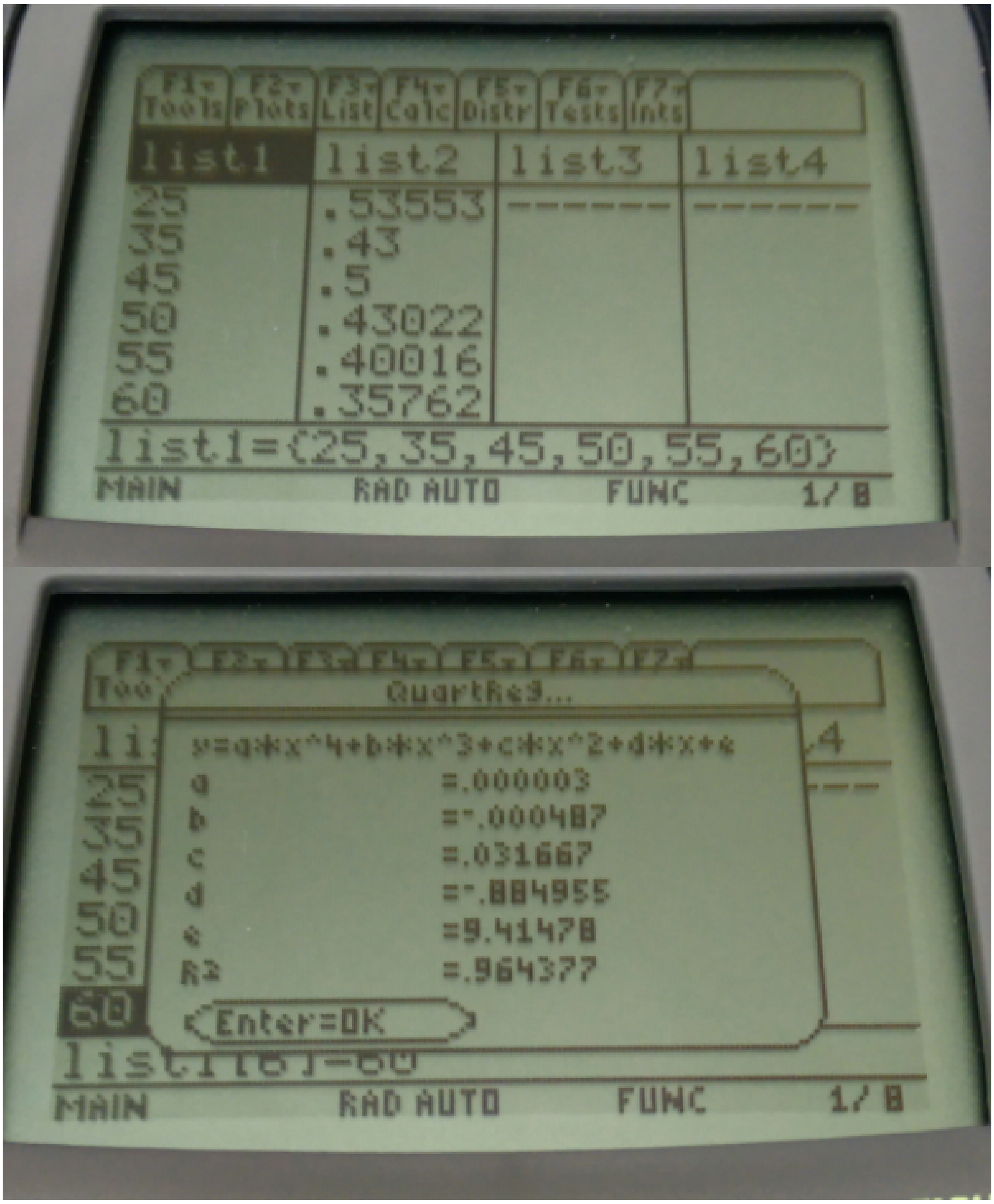


Figure 21 (b-t)

The model has a good robust within the range of [0.8, 1.0].

Then we came up with the relationships:

$$a = 0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292$$

Combined with the RGB%-time correlation we get earlier,

$$T = 1 - 10^{\frac{46.01 - R\%}{293}}$$

we finally arrive at the relationship between RGB% and concentration, with time being a parameter.

$$C = \left(\frac{1 - 10^{\frac{46.01 - R\%}{293}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292} \right)^{\frac{1}{0.000003*t^4 - 0.000487*t^3 + 0.031667*t^2 - 0.884955*t + 9.41478}}$$

$$C = \left(\frac{1 - 10^{\frac{G\% - 33.22}{441}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292} \right)^{\frac{1}{0.000003*t^4 - 0.000487*t^3 + 0.031667*t^2 - 0.884955*t + 9.41478}}$$

$$C = \left(\frac{1 - 10^{\frac{30.662 - B\%}{734}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292} \right)^{\frac{1}{0.000003*t^4 - 0.000487*t^3 + 0.031667*t^2 - 0.884955*t + 9.41478}}$$

1. Discussion

We've constructed a mathematical model serving as a complementary to the part that cannot be completed due to the limitations of our laboratory. Here, we determine the relationship between color of the test paper and the concentration, providing way for our HCV Hunter paper to be efficiently used and interpreted. And after this part the project was thoroughly finished. And now the benefits of the combination of toehold switch and test paper are obvious. The facts that test papers are easier to carry out of the lab and that test papers are easier to operate enable the popularization of test paper. The toehold switch, meanwhile, add up to the accuracy of RNA detection.

2. Conclusion

By using RGB model, excel, photoshop and matlab, we successfully built up the correlation between RGB%, concentration of HCV in the sample, with time being a parameter.

References:

Published papers:

[1] Keith Pardee, Alexander A. Green, Tom Ferrante, D. Ewen Cameron, Ajay DaleyKeyser, Peng Yin, and James J. Collins.(2014). Paper-Based Synthetic Gene Networks. *Cell.* **159**, 940–954 (2014).

Website

[2] Anonymous, RGB Model, Wikipedia. https://en.wikipedia.org/wiki/RGB_color_model. Accessed: 24 September 2016, at 11:32.

Appendices:

Appendix A MATLAB Code of The Three-dimensional RGB Graph

Appendix B Data\

$$R\% = -0.293t + 44.61$$
$$G\% = -0.441t + 46.01$$
$$B\% = 0.734t + 9.376$$
$$A = 0.001t - 0.029$$
$$R\% = -293A + 53.107$$
$$G\% = -441A + 22.221$$
$$B\% = 734A + 30.662$$
$$A = \lg(\frac{1}{(1-T))} /$$
$$T = \left|1 - \frac{1}{10^{A}}\right| * 100\%$$
$$T = 1 - 10^{\frac{46.01-R\%}{293}}$$
$$T =$$
$$T =$$
$$T = a * C^{b}$$
$$a = 0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292$$
$$b = 0.000003 * t^4 - 0.000487 * t^3 + 0.031667 * t^2 - 0.884955 * t + 9.41478$$

$$C = \left(\frac{1 - 10^{\frac{46.01-R\%}{293}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292}\right)^{\frac{1}{0.000003*t^4-0.000487*t^3+0.031667*t^2-0.884955*t+9.41478}}$$

$$C = \left(\frac{1 - 10^{\frac{G\%-33.22}{441}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292}\right)^{\frac{1}{0.000003*t^4-0.000487*t^3+0.031667*t^2-0.884955*t+9.41478}}$$

$$C = \left(\frac{1 - 10^{\frac{30.662-B\%}{734}}}{0.000236 * t^3 - 0.025709 * t^2 + 0.996969 * t - 12.3292}\right)^{\frac{1}{0.000003*t^4-0.000487*t^3+0.031667*t^2-0.884955*t+9.41478}}$$

C=Concentration

A=Absorbance

R%=$\frac{R}{R+G+B} * 100\%$

G%=$\frac{G}{R+G+B} * 100\%$

B%=$\frac{B}{(R+G+B)} * 100\%$

T=Transmission

T=Time

a=the speed of producing

b=